Promotion of SNCR by Sodium Compounds

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Disadvantages of SNCR methods include narrow temperature window and low N-agent utilization. It has been shown [1-4] that hydrogen, hydrogen peroxide, hydrocarbons, alchohols, carbon monoxide and other additives can shift the active temperature window towards lower temperatures. However, side effects of additives injection (depending on their nature) are higher CO emissions, formation of byproducts and sometimes lower optimum NO_x control efficiencies.

Recent research at EER [5, 6] showed that some difficulties of the SNCR methods can be alleviated by injection of inexpensive, non-toxic inorganic compounds along with the NH_i radical precursor. They can be added in amounts that are small relative to the NO_x concentration and to the concentration of metals commonly present in coal. The data showed that addition of sodium salts extended the SNCR temperature window to lower temperatures and enhanced the NO_x reduction efficiencies of both ammonia and urea achieving about 90% NO_x reduction at 1250 K. In addition, N_2O formation was reduced.

Pilot-scale experiments on the influence of NaOH, $NaHCO_3$ and Na_2CO_3 on the SNCR process were conducted in the 300 kW Boiler Simulator Facility. The amount of NO in the mixture was 200 and 500 ppm, and NSR ($[NH_3]/[NO]$ molar ratio) was 1.0 and 1.5. The presence of Na-containing compounds deepens and widens the temperature window in comparison with injection of NH_3 alone. When present at the same Na atom amounts, efficiencies of NaOH, $NaHCO_3$ and Na_2CO_3 additives were found to be about the same.

The reaction mechanism used for modeling was composed by combining the Na-O-H chemistry of Perry and Miller [7] with the N-H-O chemistry of Miller and Glarborg [8]. Since it was found that NaOH, $NaHCO_3$ and Na_2CO_3 have equal efficiencies, modeling was conducted under assumption that Na is injected in the form of NaOH.

Calculations showed that most of Na during reaction is present in the form of NaOH (thermodynamically the most stable form of Na at these temperatures). However, some of NaOH was converted into other species. The main conversion of Na went through the chain sequence

$$NaOH \rightarrow NaO_2 \rightarrow Na \rightarrow NaO \rightarrow NaOH.$$

When added, reactions that define the above chain come to the net reaction

$$H_2O + HO_2 \rightarrow 3OH.$$

Modeling thus demonstrated that the promoting effect of NaOH can be attributed to enhanced radical concentrations due to reactions of Na species. These reactions lead to a continuous supply of OH radicals that can react with NH_3

$$NH_3 + OH \rightarrow NH_2 + H_2O$$

such that the efficiency of NH_3 as NO removing agent acting through

$$NH_2 + NO \rightarrow N_2 + H_2O$$
$$NH_2 + NO \rightarrow N_2H + OH$$

in the conventional SNCR manner is significantly enhanced by NaOH addition. This effect becomes especially pronounced at low temperatures when generation of active centers by the N-H-O system itself slows down, and addition of Na containing species accelerates the radical initiation process.

Modeling results demonstrate good agreement with experimental data on promotion of NO_x reduction in the presence of Na-containing species for both ammonia and urea injection. The suggested mechanism can be used for optimization of SNCR processes promoted by small additives of Na-containing species.

References

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